

# The Relation between Respiratory Illness in Primary Schoolchildren and the Use of Gas for Cooking

## I - Results from a National Survey

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Melia R J W (Department of Community Medicine, St. Thomas's Hospital Medical School, London SE1), Florey C du V and Chinn S. The relation between respiratory illness in primary schoolchildren and the use of gas for cooking I - results from a national study. *International Journal of Epidemiology* 1979, 8: 333-338.

The relation between the prevalence of respiratory illness and use of gas for cooking in the home has been investigated in a 5 year longitudinal study of primary schoolchildren from England and Scotland. 4827 boys and girls aged 5 to 10 years from 27 randomly selected areas were examined in 1977, the last year of the study. The prevalence of one or more respiratory symptoms or diseases was higher in children from homes where gas was used for cooking than in those from homes where electricity was used. The association appeared to be independent of age, sex, social class, number of cigarette smokers in the home and latitude but it was only found in urban areas (for boys  $p < 0.005$ ; for girls  $p = 0.08$ ). In children aged from 6 to 7½ in 1973 who were followed until the last year of the study there was some indication that the association between respiratory illness and gas cooking may have disappeared as the children grew older. However this trend was not obvious in the other age groups who were followed for 2 to 4 years. The evidence of an association between gas cooking and respiratory illness in 1977 supports results for 1973 presented in an earlier report while the cohort results provide some indication that the association may disappear as children grow older.

We previously reported an association between the prevalence of respiratory symptoms and disease, and the use of gas for cooking using data from a national study of respiratory illness in primary schoolchildren (1). We believed that indoor air pollution from nitrogen dioxide ( $\text{NO}_2$ ) formed during the combustion of gas might have been the cause of this association because this pollutant has been shown to increase susceptibility to respiratory infection in animals (2). In this series of 3 papers we present an analysis of more recent data from our national study and also the results of an investigation of the relation between children's respiratory illness and  $\text{NO}_2$  levels in the home (3, 4).

As the national study was longitudinal and the association had only been reported for children present in the first year, 1973, we examined the

data collected over the 4 following years. Results are reported here for 2 groups of children: those aged 5 to 10 years who were present in 1977 but not 1973 (cross-sectional analysis), and those present in 1973 who were followed-up in subsequent years (cohort analysis). Unlike previous years, in 1977 information was collected on the number of people who smoked cigarettes, cigars and pipes in the home. Additional information was collected on gas water heaters and use of pilot lights on gas cookers as it was thought that these might contribute to the concentration of  $\text{NO}_2$  in the home.

### METHODS

Children aged 6 to 11 years who attended schools in 28 randomly selected areas of England and Scotland were examined annually from 1973 to 1977. The areas were selected from 597 employment exchange areas by stratified random sampling and a socio-economic index was used to obtain a high proportion of poor areas. Details of the method

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TABLE 1 *Crude prevalence (%) of respiratory symptoms and diseases in boys and girls by type of fuel used for cooking in the home*

Symptoms and Diseases	Electricity	Boys Gas	P*	Electricity	Girls Gas	P*
Morning cough	2.1	3.1	<0.20	2.4	3.3	p>0.20
Day or night cough	4.2	6.3	=0.02	4.4	4.7	p>0.20
Wheeze	10.1	10.1	p>0.20	6.2	7.1	p>0.20
Colds going to chest	23.2	26.4	p<0.10	19.6	23.1	p<0.05
Asthma	2.4	2.4	p>0.20	1.0	1.2	p>0.20
Bronchitis	3.2	3.6	p>0.20	2.2	2.4	p>0.20
Any respiratory illness	26.3	31.2	p=0.01	23.1	26.5	p=0.07
No. children	1549	909		1468	901	

\* Probability value of difference between prevalence rates  $\chi^2$  test

of sampling are described elsewhere (5).

In 1977, however, schools from 4 areas were unable to participate and other state schools in the areas were selected. A further 4 areas declined to take part at all and nearby areas with the same socio-economic index were substituted. One of the new areas was not ready to join the study in 1977 so the children came from 21 English and six Scottish areas. The age range was extended in 1977 to include 5 year olds.

Information about each child and the home environment came from a questionnaire completed by the child's mother or other guardian. Six questions used in the previous years of the study were asked about cough, wheeze, colds going to the chest, and the number of attacks of asthma and bronchitis experienced by the child during the previous 12 months. Other questions were asked about the type of fuels used for cooking and heating in the home, the presence of gas water heaters, the use of pilot lights on gas cookers, and the number of people in the household who smoked cigarettes (at least 5 a day) and cigars or pipes regularly. The father's occupation was coded into social class using the Registrar General's classification (6) and the numbers of bedrooms and people in the household were used to obtain a measure of overcrowding.

#### *Population for 1977 Cross-Sectional Analysis*

9925 children were included in the study in 1977 but 1330 10 to 11 year olds were excluded because they had also been present in 1973 and we wished to study a different group of children from those among whom the effect of gas cooking had first been found. Out of the remaining 8595, 271 were omitted because their ethnic group was either not

known or known to be non-Caucasian, 88 because their age was not known and 261 because they were aged less than 5. 5008 (63%) of the remaining 7975 children had complete information on the 6 respiratory symptoms and diseases, their father's social class, the number of cigarette smokers in the home and type of fuel used for cooking. 181 of these were excluded because they did not come from homes where only electricity or only gas was used for cooking. As the numbers of cigar and pipe smokers in the home tended to be associated with the number of cigarette smokers we used only the latter in the analysis as a general indicator of smoking in the home. The analysis was carried out on 3017 children from homes with an electric cooker and 1810 from homes with a gas cooker. This 62% sample of the total 7794 children eligible for analysis showed no significant difference in mean height or weight by age from the remaining 38% whose measurements had also been taken. For 2 additional analyses 98% of the 4827 children had information on gas water heaters and 99.6% of those from homes with a gas cooker had data on pilot lights.

#### *1973 Cohort Analysis*

Children first examined in 1973 left the study when they left primary school at age 11 or 12, or if they moved away from their area. They could be divided into 5 cohorts according to the number of completed years for which they remained in the study (less than 1 to 4). In our analysis we have considered only children who had been followed-up for at least one year and whose mother had reported the use of the same cooking fuel in each year that their child was studied. There were insufficient numbers for

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analysis of those who reported a change in cooking fuel. 5758 (73%) of the 7851 Caucasian children aged 6 to 11 years who were included in the study in 1973 had complete information on sex, social class and the 6 respiratory symptoms and diseases, and came from homes where only gas or electricity was used for cooking. Of these 5758, 2408 (42%) had data for full follow-up: 791 children aged 9.5 to 10.9 (14%) were followed up with complete information for one year until 1974, 578 aged 8.5 to 9.4 (10%) until 1975, 502 aged 7.5 to 8.4 (9%) until 1976 and 537 aged 6 to 7.4 (9%) until 1977.

#### CROSS-SECTIONAL RESULTS FROM 1977

##### Crude Prevalences

Only the prevalences of day or night cough in boys ( $p = 0.02$ ) and colds going to the chest in girls ( $p < .05$ ) were found to be significantly higher in children from homes where gas was used for cooking compared with children from homes where electricity was used. Although none of the other symptoms or diseases appeared to have a statistically significant association with gas cooking the prevalences of all symptoms and diseases in girls and of morning cough, colds going to the chest and bronchitis in boys appeared to be higher in children from homes with gas cookers.

As no particular symptom or disease showed a strong association with type of cooking fuel in either sex and the responses to the 6 respiratory questions were inter-related we grouped the various

responses to the 6 respiratory questions by a method similar to that used in our previous paper (1). The children were grouped according to whether they had none, or one or more symptoms or diseases. In both sexes this prevalence was higher in children from homes where gas was used for cooking than in those from homes where electricity was used ( $p = 0.01$  in boys,  $p = 0.07$  in girls).

##### Prevalence and related factors

Several interfering factors needed to be considered in the analysis. The most obvious of these were age and social class (Table 2). Within each age group (less than 8, and 8 or more) and each social class group (I to III (non-manual), and III (manual) to V) the risk of having one or more respiratory symptoms or diseases in homes with gas cookers relative to the risk in homes with electric cookers was greater for all children except girls aged 8 or more from the manual social classes. The weighted relative risk (7) across these groups in homes with gas compared with homes with electric cookers was 1.25 for boys ( $p < 0.05$ ) and 1.19 for girls ( $p = 0.07$ ). The relative risk in boys was similar to that for boys aged 6 to 11 who had been examined in 1973 (1.29,  $p < 0.05$ ) but in girls the relative risk was smaller in 1977 than 1973 when the value was 1.40 ( $p < 0.001$ ).

In addition to age and social class we also considered the number of cigarette smokers in the home. The number of smokers was associated with

TABLE 2 Percentage of boys and girls classified by the number of respiratory symptoms and diseases that they were reported to have, social class, age and type of fuel used for cooking. Risk of having respiratory illness in homes with gas cooking relative to risk in homes with electric cooking also given.

SEX	No. Respiratory Symptoms or Diseases	SOCIAL CLASS I-III (non-manual)				SOCIAL CLASS I-III (manual) - V			
		< 8 Years		> 8 Years		< 8 Years		> 8 Years	
		Electricity	Gas	Electricity	Gas	Electricity	Gas	Electricity	Gas
BOYS	None	72.6	68.3	80.8	71.7	67.2	63.3	76.4	73.1
	1 or more	27.4	31.7	19.2	28.3	32.8	36.7	23.6	26.9
	TOTAL †	100	100	100	100	100	100	100	100
		(277)	(145)	(286)	(113)	(485)	(313)	(501)	(338)
	Relative Risk	1.2		1.7*		1.2		1.2	
GIRLS	None	75.6	72.4	85.2	81.4	72.2	63.7	78.5	81.5
	1 or more	24.4	27.6	14.8	18.6	27.8	36.3	21.5	18.5
	TOTAL †	100	100	100	100	100	100	100	100
		(291)	(134)	(243)	(118)	(497)	(336)	(437)	(313)
	Relative Risk	1.2		1.3		1.5*		0.8	

\*  $p < 0.05$ . † number of children given in brackets

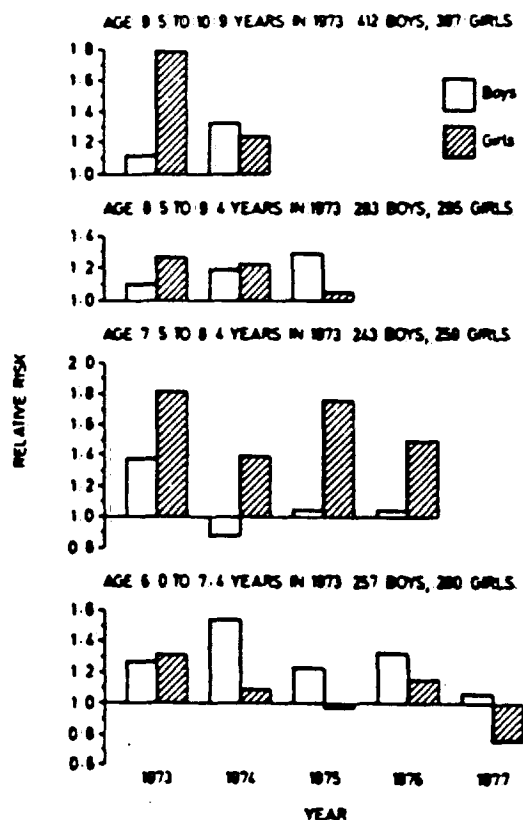


FIGURE  
The relative risk for respiratory illness in children from gas cooking homes compared with children from electric cooking homes is given by sex and year of examination for four cohorts defined by age at entry into the study in 1973.

the use of gas for cooking within manual but not non-manual social classes (Table 3). Furthermore the degree of urbanisation and location of the study areas defined by latitude (Scotland, and England divided into north and south by a line joining the

Bristol Channel to the Wash) were included in the analysis because in 1973 the association between respiratory illness and gas cooking was found to be most consistent in urban areas in the north of England.

The relation between these factors and the prevalence of respiratory illness was examined by fitting a log-linear model using a method of analysis described in greater detail in our earlier paper (1). We first divided the children into 1 of 2 categories according to whether they had none, or one or more symptoms or diseases. We then divided the children by age, sex, social class and type of cooking fuel as shown in Table 2, into rural and urban areas (less than 20, and 20 or more persons per hectare respectively) and the 3 divisions of latitude. The model was fitted separately for boys and girls, and for rural and urban areas as the computer program did not allow space for the full model.

An association between gas cooking and respiratory illness was found independent of the effects of the other factors in urban areas (for boys  $p < 0.005$ , for girls  $p = 0.08$ ) but not rural ones. For girls in rural areas, however, there appeared to be an association in the younger age group. In contrast the effect of number of smokers in the home was only significant in rural (for both sexes  $p < 0.005$ ) but not urban areas. As might have been expected the prevalence was higher in the younger than the older age groups ( $p < 0.05$ ) in all 4 analyses and tended to be higher in the manual than the non-manual social classes although this relation was not always significant. An effect of latitude was only found in girls from urban areas ( $p < 0.05$ ), the prevalence being highest in the north and lowest in the south of England.

We extended the 1977 analysis to allow for the effects of various other factors: overcrowding, type of fuel used for heating in the home and outdoor levels of smoke and sulphur dioxide in each area. Only 1032 boys and 950 girls could be included in

TABLE 3 Percentage of children living in homes with no cigarette smokers and one or more smokers by the father's social class and type of fuel used for cooking in the home.

No Cigarette Smokers	Social Classes I-III (non-manual)		P	Social Classes III (manual) - V		P
	Electricity	Gas		Electricity	Gas	
None	55.4	58.8		38.3	28.5	
1 or more	44.6	41.2	= 0.20	61.7	71.5	<0.001
TOTAL *	100	100		100	100	
	(1097)	(510)		(1920)	(1300)	

\* Number of children given in brackets.

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TABLE 4 Crude prevalence (%) of having one or more respiratory symptoms or diseases in boys and girls by presence of gas water heaters in the home and use of pilot lights on gas cookers

SEX	Presence of Gas Water Heater			Use of Pilot Light *		
	No	Yes	P	No	Yes	P
BOYS†	27.7 (2253)	33.3 (141)	< 0.20	30.8 (305)	31.4 (598)	p > 0.20
GIRLS†	23.9 (2201)	33.9 (121)	< 0.02	23.2 (310)	28.3 (590)	p < 0.15

† number of children given in brackets

\* children from homes with electric cooking excluded

this analysis so these findings must be treated with caution. However, after allowing for the various effects, respiratory illness was shown to be associated with gas cooking although only significantly so in boys (for boys  $p < 0.02$ ; for girls  $p = 0.15$ ).

Finally we examined the effects of gas water heaters and pilot lights (Table 4) but a relation could only be found between respiratory illness in girls and gas water heaters. When we fitted a log-linear model to include age, social class, and number of smokers in the home in the analysis, the association between water heaters and respiratory illness was inconsistent across the 2 social class and cooking fuel groups. However a significant association was found in girls after allowing for the effects of the other factors ( $p < 0.05$ ).

## LONGITUDINAL RESULTS FOR 1973 COHORTS

For the 4 cohorts of children who were followed up for 1 to 4 years, the risk of having one or more respiratory symptoms or diseases in homes with gas cookers relative to the risk in homes with electric cookers was calculated for each sex in each year that the children were examined (Figure).

In each cohort in 1973 the risk was greater in homes with gas than homes with electric cookers. In later years, as the cohorts grew older, the relative risk showed considerable variation. Although in most groups the risk was greater in homes with gas than homes with electric cookers, there were groups for whom the risk was either negligible or greater in homes with electric cookers. For each cohort there appeared to be no consistent change in the size of relative risk over time except possibly in the youngest cohort for which the relative risk tended to decline from 1973 to 1977.

## DISCUSSION

Although the results for the children seen in 1977

were similar in many respects to those for children seen in 1973 there were differences. The effect of gas cooking seemed to be smaller in 1977 than in 1973, at least among girls and, whereas the effect had been most consistent in urban areas in the north of England in 1973, it appeared to be independent of latitude in 1977.

As the prevalences tended to be higher in 1973 than 1977 for children of the same age it is possible that children examined in the first year were predisposed to respiratory illness through the effect of some other factor and were therefore more susceptible to the effect of gas cooking. Differences in weather conditions between the 2 years would not explain these observations as the winter of 1976/77 was colder than that of 1972/73. However as the levels of outdoor air pollution from smoke and sulphur dioxide have been declining over a number of years in the United Kingdom (8) children studied in the first year may have been exposed to higher levels of outdoor air pollution during their lives than children examined in the last year. As the decline in these levels is likely to have been most marked in urban areas in the north of England this may explain why the effect of gas cooking was no longer most consistent in this type of area by 1977. Past high levels of atmospheric pollution may also have contributed to the differences in longitudinal results between the cohorts first examined in 1973.

There seems to be no obvious reason why there should be a gas cooking effect in urban areas and a smoking effect in rural areas. We can only suggest that variation in the size of effects has occurred by chance because the sample of children has been subdivided into so many small groups during the analysis. Similarly, as the effect of gas water heaters was only found in girls, a more thorough investigation would be required before drawing conclusions from this result.

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In summary we have observed an association between respiratory illness and the use of gas for cooking in 2 separate groups of children seen 4 years apart in our national study. However the relative risk for children in homes with gas cookers compared with those in homes with electric cookers appears to be smaller in 1977, at least in girls, and only significant in urban areas. There is also some evidence that the relative risk may decline as the children grow older.

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#### REFERENCES

- (1) Melia R J W, Florey C du V, Altman D G and Swan A V. Association between gas cooking and respiratory disease in children. *British Medical Journal* ii: 149-152, 1977.
- (2) Erhlich R, and Henry M C. Chronic toxicity of nitrogen dioxide. I. Effect on resistance to bacterial pneumonia. *Archives of Environmental Health* 17: 860-865, 1968.
- (3) Goldstein B D, Melia R J W, Chinn S, Florey C du V, Clark D and John H II. The relation between respiratory illness in primary schoolchildren and the use of gas for cooking. II. Factors affecting nitrogen dioxide levels in the home. *International Journal of Epidemiology* 8: 339-345, 1979.
- (4) Florey C du V, Melia R J W, Chinn S, Goldstein B D, Brooks A G F, John H H, Craighead I B, and Webster X. The relation between respiratory illness in primary schoolchildren and the use of gas for cooking. III. Nitrogen dioxide, respiratory illness and lung function. *International Journal of Epidemiology* 8: 347-353, 1979.
- (5) Altman D G, and Cook J. A nutritional surveillance study. *Proceedings of the Royal Society of Medicine* 66: 696-697, 1973.
- (6) Office of Population Censuses and Survey. Registrar General's Classifications of Occupations, 1970. HMSO, London, 1970.
- (7) Armitage P. Statistical Methods in Medical Research. 4th Edition, p 427-433 Blackwell, Oxford, 1977.
- (8) Weatherley M-L, P M, Gorrish B D and Charnock J. Fuel consumption, smoke and sulphur dioxide emissions and concentrations, and grit and dust deposition in the UK, up to 1973-74. LR 214(AP), Warren Spring Laboratory, Stevenage, 1976.

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